PATENT APPLICATION
DOCKET NO. OKC00128.1

APPLICATION

Of

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For

UNITED STATES LETTERS PATENT

On

LIQUID/VAPOR BYPASS VALVE

Docket OKC00128.1
Sheets of Drawings: 5

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LIQUID/VAPOR BYPASS VALVE

Related Applications

This application claims priority to United States Provisional Application No. 60/450,999 filed February 28, 2003, entitled Multi-Phase Valve Assembly.

Field of the Invention

This invention is generally directed to fluid delivery systems and more particularly, but without limitation, to a bypass valve assembly establishing a bypass path when pressure exceeds or falls below set threshold limits.

Background

Pressure relief bypass valves are often used in fluid delivery systems to establish a bypass path in the event of an overpressure condition. A typical bypass valve includes a spring-loaded piston seated on an internal orifice of a pump or other system member. The spring biases the piston into a sealed or closed position, and when the system pressure reaches a level sufficient to overcome the preset bias of the spring – sometimes referred to as the differential pressure set point - the piston is lifted from the orifice to allow fluid flow there through.

While effectively compensating for liquid overpressure conditions, bypass valves have not historically aided in the resolution of underpressure conditions, such as when a delivered fluid transitions to a vapor phase and/or entrained air condition. A fluid delivery system of interest is one that is carried out by

connecting a hose from a tank of a delivery vehicle to a customer tank. The fluid is typically a liquid/vapor fluid that is pumped and metered from the vehicle to a customer's tank.

In the case of a vaporous fluid, such as hydrocarbon fuels like fuel oil and diesel, government regulations consider the delivery vehicle to constitute the point of sale and prohibit the sale of vapor and/or air, such as can occur should the delivery tank be emptied of liquid and the pump continue operating. Such systems often utilize a positive displacement pump that continues to deliver vapor and/or air after the delivery tank has been emptied of liquid.

Meters in the past were often provided with vapor eliminator stages to prevent the metering of vapor, but such meters have not always been effective as they can be overloaded and do nothing to prevent or alleviate the pumping of the fluid when a transition occurs to the vapor state.

There is therefore a continuing need for a bypass valve that effectively compensates for both overpressure and underpressure conditions, and which accommodates vapor phase conditions in fluid delivery systems. It is to such an improvement that the present invention is generally directed.

Summary of the Invention

The present invention provides a bypass valve assembly which selectively operates to establish a bypass path for a fluid delivery system, the bypass valve assembly having a housing or body member with a fluid inlet that is connectable to the delivery system and is connectable to a bypass fluid outlet conduit. A slidable piston assembly is supported in the body and is moveable to a one of a closed position, a first open position and a second open position. In the closed position

the piston assembly is positioned to prevent fluid flow from the inlet to the bypass fluid outlet.

Also provided are means that bias the piston assembly to the closed position when the pressure in the delivery system is between an upper first threshold pressure value and a lower second threshold pressure value. When the delivery system pressure exceeds the first threshold pressure value, said means moves the piston assembly to the first open position to permit fluid flow to the bypass fluid outlet; and when the delivery system pressure is less than the second threshold pressure value, said means moves the piston assembly to the second open position so that fluid flow is permitted from the fluid inlet through the bypass fluid outlet.

The features, advantages and objects of the present invention will be apparent from reading the following detailed description together with the drawings and claims.

Brief Description of the drawings

FIG. 1 is a schematic block diagram of a fluid delivery system incorporating the bypass valve assembly of the present invention.

FIG. 2 is a semi-detailed, elevational cross-sectional view of the bypass valve assembly of the present invention.

FIG. 3 is a perspective view of the slidable cage assembly of the bypass valve assembly of FIG. 2.

FIG. 4 is a perspective view of the piston assembly of the bypass valve assembly of FIG. 2.

FIG. 5 is a semi-detailed, elevational cross-sectional view of the bypass valve assembly of FIG. 2 during an overpressure condition, the system pressure having exceeded a predetermined upper threshold pressure value.

FIG. 6 is a semi-detailed, elevational cross-sectional view of the bypass valve assembly of FIG. 2 during an underpressure condition, the system pressure having dropped to below a predetermined lower threshold pressure value.

Detailed Description

As embodied herein, the present invention is generally directed to a bypass valve assembly that compensates for both liquid overpressure conditions and underpressure conditions in a fluid delivery system, the underpressure condition occurring when a vapor phase of the delivery fluid and/or air is encountered. Reference is first made to FIG. 1, in which is provided a simplified schematic block diagram of a fluid delivery system **100** in which a liquid is delivered from a source vessel to a target vessel. The source vessel typically is a tank on a delivery vehicle, the fluid is a hydrocarbon fuel and the target vessel is a customer tank.

A pump **102** (typically a rotary pump) receives fluid from a suction inlet conduit **104**. The pump **102** discharges the fluid to an outlet conduit **106** at a pressure nominally higher than that in the inlet conduit **104**. The particular internal configuration of the pump **102** can take a number of forms, and further details of such are omitted for clarity of discussion. For a description of a rotary pump suitable for use as the pump **102** in the fluid delivery system **100**, see U.S. Patent No. 5,921,274 issued to Schuller et al., assigned to the assignee of the present application and incorporated herein by reference. Further, numerous valves, piping and control mechanisms commonly incorporated in fluid delivery systems are

omitted herein as a description of such, being well known to those skilled in the art, are believed to be unnecessary for an understanding of the present invention.

A first bypass conduit **108** is in fluid communication with the fluid outlet conduit **106** and is connected to a bypass valve assembly **110**. A second bypass conduit **111** is connected by its proximal end to the first bypass conduit **108** and is connected to the bypass valve assembly **110** at its distal end.

As shown in FIG. 2, the bypass valve assembly **110** has a piston assembly **112** and a slidable cage assembly **114**, which are shown individually in FIGS. 3 and 4, respectively. With reference to FIG. 3, the cage assembly **114** is preferably formed from stainless steel or other suitably rigid, durable material. The cage assembly **114** has a plunger member **116** that has opposing surfaces **118**, **119**, and a circumferentially extending, recessed O-ring seal **120**. Standoff flange members **122** project upwardly from the plunger **116** to support an annular collar **124** that has a central orifice **126**.

The piston assembly **112**, shown more clearly in FIG. 4, is also preferably formed of stainless steel or other suitable, rigid and durable material and is configured to be slidingly supported within the central orifice **126** of the cage assembly **114**. The piston assembly **112** includes a disc-shaped base **130** that has opposing seat surfaces **132**, **134**. A cylindrical spring guide member **136** projects downwardly from the base **124**. A cylindrical flow member **138** extends upwardly from the base **124** and includes an entrance orifice **140** and a number of angularly spaced apart exit orifices **142**.

The cage assembly **114** and piston assembly **112** are supported in a housing or body member **144**, as shown in FIG. 2. The body **144** has an inlet **146** which is connectable to the first bypass conduit **108** to receive pump discharged fluid from

the fluid outlet conduit **106** (FIG. 1). The body **144** further includes a bypass outlet **148** in fluid communication with a bypass discharge conduit **149** (FIG. 1). The body has a bonnet portion **150** that seals the lower end of the body **144**, forming an interior chamber **152** below the cage assembly **114**. The bonnet portion **150** has a pressure inlet orifice **154** communicating with the interior chamber **152** and connectable to the second bypass conduit **111** to assert fluid pressure on the lower surface **119** of the plunger **116**.

A coiled first spring **156** has a first end which bears against the top surface **118** of the plunger **116**, and a second end which wraps around the spring guide member **136** and bears against the base **130** of the piston assembly **112**. A coiled second spring **158** is disposed between an insert **160** in the body **144** and the cage assembly **114** to exert a downwardly directed force on the cage assembly **114**.

To explain the configuration of the bypass valve assembly **110** under various operational conditions, the following force values will first be defined. As shown in FIG. 2, force **F1** denotes the generally downwardly directed force upon the piston assembly **112** by the fluid pressure at the inlet **146**. Force **F2** denotes the generally upwardly directed force by the fluid pressure on the lower surface **119** of the plunger **116** by fluid entering the chamber **152** via the pressure inlet orifice **154** and the second bypass conduit **111**.

Because the lower surface **119** of the plunger **116** has a substantially larger surface area than that of an interior surface **162** of the piston assembly **112**, and the respective fluids provided to the inlet **146** and to the pressure inlet orifice **154** are at nominally the same pressure, the force **F2** will generally be substantially greater than the force **F1**. This will hold true regardless of the particular pressures of the respective fluids at the inlet **146** and the inlet orifice **154**.

Force **F3** denotes the force exerted by the first spring **156** on the piston assembly **112** with respect to the cage assembly **114**. Force **F4** denotes the force exerted by the second spring **158** on the cage assembly **114** with respect to the body **144** (via insert **160**).

FIG. 2 shows a preferred configuration of the bypass valve assembly **110** during normalized pressure operation of the system **100** as the transported fluid is pumped in a liquid state within a selected operational pressure range. During such operation, the piston assembly **112** remains seated in a closed position (preferably via a metal to metal seal at annular junction **164**), effectively sealing off the bypass outlet **148** from the inlet **146**. This state is maintained because the following relations are met:

$$\mathbf{F2} > \mathbf{F1} + \mathbf{F4}; \text{ and} \qquad (1)$$

$$\mathbf{F3} > \mathbf{F1}$$

That is, the force exerted upon the plunger **116** (**F2**) exceeds the combined force of the inlet fluid against the piston assembly **112** (**F1**) and the force of the second spring **158** (**F4**) against the cage assembly **114**. Also, the piston assembly **128** remains biased upwardly against the collar **124** of the plunger **116** of the cage assembly **114** because the force of the first spring **156** (**F3**) exceeds the inlet fluid force (**F1**).

FIG. 5 shows a preferred configuration of the bypass valve assembly **110** during an overpressure condition of the system during which the transported fluid pumped by the system **100** exceeds a predetermined upper threshold pressure value. During such operation, the piston assembly **112** moves to a first open position, permitting fluid flow through the inlet **146**, through the exit orifices **142** of the piston assembly **112**, through the cage assembly **114** (via the openings

between the standoffs **122**) and out the bypass outlet **148**. It will be noted that the cage assembly **114** remains positioned as shown in FIG. 2, but the piston assembly **112** has moved relative thereto. This state can be described as follows:

$$\mathbf{F2} > \mathbf{F1} + \mathbf{F4}; \text{ and} \qquad (2)$$

$$\mathbf{F1} > \mathbf{F3}$$

In this regard, the bypass valve assembly **110** generally operates in a conventional fashion; that is, the force of the inlet fluid (**F1**) at inlet conduit **146** is sufficient to compress the first spring **156** (which exerts **F3**) and move the piston assembly **112** downwardly in the body **144** and away from its normally closed position to the first open position.

FIG. 6 shows a preferred configuration of the bypass valve assembly **110** during an underpressure condition of the system during which the transported fluid pumped by the system **100** falls below a predetermined lower threshold pressure value. For example, as discussed above, this can occur during the transition of a transported pressurized fluid from a liquid state to a vapor state, which will tend to result in a significant drop in the fluid pressure.

Thus, during operation of the valve assembly **110** as depicted in FIG. 6 during a low pressure condition, the piston assembly **112** remains fixed relative to the cage assembly **114**, but the piston assembly **112** and the cage assembly **114** advance together downwardly, thereby moving the piston assembly to a second open position in which fluid flow is permitted from the inlet **146** to the bypass outlet **148**. Operation of the system under such condition can be described as follows:

$$\mathbf{F4} > \mathbf{F2} - \mathbf{F1}; \text{ and} \qquad (3)$$

$$\mathbf{F3} > \mathbf{F1}$$

It will be noted that in this condition, the force (**F4**) of the second spring **158** is sufficient to overcome the difference between the fluid forces **F2** and **F1**, and the plunger **116** moves down to abut the bonnet **150**. FIG. 6 also represents the steady state condition of the piston assembly **112** of the bypass valve assembly **110** when no fluid pressure is present (such as during a nonoperational, nonpressurized state of the system **100**).

From the foregoing discussion it will be apparent that the relative surface areas of the interior surface of the piston assembly **112** and the lower surface **119** of the plunger **116**, and the respective spring forces of the first and second springs **156**, **158**, are preferably selected to meet the above conditions set forth by equations (1) through (3) for a given upper threshold pressure value and a lower threshold pressure value. While coiled springs (such as **156, 158**) have been disclosed as a preferred manner in which to apply biasing forces to the piston assembly **112** and the cage assembly **114**, it will be recognized that any number of other methodologies could readily be employed to supply the respective operational forces.

Moreover, while preferred embodiments have contemplated the underpressure condition arising as a result of a transition from a liquid phase to a vapor phase for the transported fluid, such is not limiting to the scope of the invention. Rather, the bypass valve assembly can readily be configured to operate to detect and establish bypass paths for any desired upper and lower pressure thresholds, regardless whether the fluid undergoes a state transition (e.g., from a liquid to a vapor).

Based on the foregoing, it will now be understood that the present invention is generally directed to the above described subject matter, without limitation.

While the present invention has been described with the reference to a preferred embodiment thereof, those skilled in the art will appreciate various changes in form and detail may be made without departing from the intended scope of the present invention as defined in the appended claims.